On the rank deficiency of BIE/BEM using degenerate kernels

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In the past decades, the boundary integral equation (BIE) as well as the boundary element method (BEM) attracts mathematician and engineers, respectively. However, rank deficiency due to degeneracy occurs, e. g., degenerate boundary, degenerate scale, spurious eigenvalue and fictitious frequency. Results by using commercial codes of BEM may result in ghost solutions which mislead engineers. Mathematicians may be interested in this topic while engineers may be not capable to interpret the numerical outcome. As the vice president of Taiwan Society of Industry and Applied Mathematics (TwSIAM), I should fill in the gap and link students from math and engineering departments. Although degenerate kernel plays an important role in the theory of integral equations and gives a natural approximation, the use in engineering problems seems to have taken a back seat to other methods such as quadrature and collocation. In this regard, we will demonstrate the power how the degenerate kernel can explain the rank-deficiency mechanism of degenerate boundary, degenerate scale, spurious eigenvalue and fictitious frequency. A circle, ellipse and line crack as well as sphere, prolate and oblate spheroids will be illustrated. Besides, the treatment of rank deficiency will be also addressed. Once the degenerate kernel is available, the integral equation is nothing more than the linear algebra.

Prerequisite

Integral equations, potential theory, boundary element. Some experience in programming.

References

1. H.-K. Hong and J. T. Chen, 1988, Derivations of Integral Equations of Elasticity, Journal of Engineering Mechanics, ASCE, Vol.114, No.6, pp.1028-1044.
2. J. T. Chen and H.-K. Hong, 1999, Review of dual boundary element methods with emphasis on hypersingular integrals and divergent series, Applied Mechanics Reviews, ASME, Vol.52, No.1, pp.17-33.
3. J. T. Chen, J. H. Lin, S. R. Kuo and Y. P. Chiu, 2001, Analytical study and numerical experiments for degenerate scale problems in boundary element method using degenerate kernels and circulants, Engineering Analysis with Boundary Elements, Vol.25, No.9, pp.819-828.
4. J. T. Chen, L. W. Liu and H.-K. Hong, 2003, Spurious and true eigensolutions of Helmholtz BIEs and BEMs for a multiply-connected problem, Royal Society London Series A, Vol.459, No.2036, pp.1891-1925.
5. J. T. Chen, S. R. Lin and J. J. Tsai, 2009, Fictitious frequencies revisited, Engineering Analysis with Boundary Elements, Vol.33, pp.1289-1301.
6. S. R. Kuo and J. T. Chen, 2013, Linkage between the unit logarithmic capacity in the theory of complex variables and the degenerate scale in the BEM/BIEMs, Applied Mathematics Letters, Vol.29, No.6, pp.929-938.
7. J. T. Chen, S. K. Kao and J. W. Lee, 2017, Analytical derivation and numerical experiment of degenerate scale by using the degenerate kernel of the bipolar coordinates. Engng. Anal Bound Elem, Vol.85, pp.70-86.
8. J. T. Chen, C. Y. Yueh, Y. L. Chang and C. C. Wen, 2017, Why dual BEM is necessary ? Engineering Analysis with Boundary Elements, Vol.76, pp.59-68.
9. S. R. Kuo, S. K. Kao, Y. L. Huang and J. T. Chen, 2019, Revisit of the degenerate scale for an infinite plane problem containing two circular holes using conformal mapping, Applied Mathematics Letters, Vol.92, pp.99-107.
10. J. W. Lee, J. T. Chen\* and C. F. Nien, 2019, Indirect boundary element method combining the CHIEF and the self-regularizations with fictitious frequencies, Journal of American Society of Acoustics, Vol.145, No.5, pp..3116-3132.

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